A Renewed Focus on Utah’s Helium Potential*

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Abstract

For nearly 100 years the naturally occurring noble gas, helium, has been documented in the gas stream of natural gas wells in eastern Utah. Demand for helium is growing and the U.S. Bureau of Land Management is nearing completion of a prolonged exit from its dominant position in the commercial helium business. This transition creates opportunity for focused exploration of helium in eastern Utah and the Four Corners region of the Colorado Plateau. As supply diminishes and global demand for helium rises, primarily in the medical, technology and defense industries, economic consideration of helium exploration and production from helium-rich gas streams outside of proven natural gas productive areas is likely to significantly increase. A volume concentration of helium found in the gas stream of 0.3% or more is considered a potential helium resource. Concentrations of helium over 7.0% are rare, yet have been discovered and documented in the gas stream of wells drilled in east central Utah.

Helium (He) forms primarily in granitic or crystalline crustal rock as the alpha decay product of various radioactive elements. In southeastern Utah, reactivation of Precambrian suture zones, formed during the initial accretion of the western North American Cordillera, may provide pathways for helium microseepage to the surface. Through groundwater interaction, the buoyant decay products of deep-seated granitic or crystalline basement rocks can travel up fractures and faults until constrained in conventional hydrocarbon traps. Mantle degassing and breakdown of uranium ore bodies within thick sequences of sedimentary rock may also contribute significantly to the accumulation of helium in the subsurface. In Utah, high helium gas is typically concentrated at the margins of proven petroleum fields in deep vertical natural gas wells with high associated concentrations of nitrogen (N₂) and/or carbon dioxide (CO₂). Helium-rich gas streams in Utah are often found reservoired below the Paradox Formation salt or below the thick Mancos Shale.

While many helium-prospective regions may exist, very few natural gas fields contain the concentrations necessary to justify a helium recovery process. Documented helium shows in Utah range from common trace amounts up to 7.31%, with the highest helium concentrations on the crest of the Harley Dome structure in east central Utah from the Entrada Sandstone reservoir. Although eastern Utah helium prospects have been documented since the early 20th century, recent renewed interest of several upstream helium exploration and production companies has
brought attention back to the helium potential of Utah. With several high-percentage helium plays and natural gas wells with associated helium concentrations at or above the 0.3% economic threshold, Utah deserves the consideration of those interested in exploring for and producing helium.
A Renewed Focus on Utah's Helium Potential

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Abstract

For nearly 130 years, the naturally occurring noble gas, helium, has been documented in the gas stream of natural gas wells in western Utah. Demand for helium is growing and the U.S. Bureau of Land Management is weighing completion of aprotected well from its dominant position in the commercial helium business. The study presented here is based on a previous exploration of helium potential in the state of Utah and the Cordova region of the Colorado Plateau. As supply diminishes and global demand for helium rates, primarily in the medical, technology and defense industries, economic constraints of helium exploration and production from helium gas streams trapped between mineral salt layers of the Paradox Formation are likely to significantly increase. A volume concentration of helium found in the gas stream of 0.3% or more is considered a target for commercialization. Research on the economic feasibility of locating helium resources in Utah and the Cordova region of the Colorado Plateau is being conducted by the State of Utah School and Institutional Trust Lands Administration.

Research Questions

1) How does helium ultimately become associated within conventional petroleum systems?
2) How is helium extracted and produced in areas outside of BLM pipeline and storage access?
3) What areas were the most prospective for helium exploration?

Primary Migration and Accumulation of Helium

Although helium is the second most abundant element in the universe and the sixth most abundant gas in our atmosphere at 0.1%, it is schematically rare on Earth. Primary migration of helium in crustal basement rocks and accumulation in the underlying sedimentary rocks is complex and may involve substantial heat loss, isotope fractionation, pressure-dependent isotope fractionation and maldistribution. The most prominent isotope helium-3 (\(^{3}He\)) is thought to exist as a byproduct in two very few nuclear reactors, but also may have been present since the formation of Earth (3.5 billion years ago). It is formed in the mantle by decay of the radioactive element Uranium (U) and Thorium (Th) and released into the atmosphere by helium gas escaping into the surface water from the basement.

Result of the study is that very high helium concentrations at the margin of petroleum systems in deep vertical natural gas wells with high associated concentrations of nitrogen (N) and carbon dioxide (CO\textsubscript{2}). Helium-rich gas streams in Utah are often found between the Paradox Formation and oil in the Mesaverde Group. While helium-rich petroleum reservoirs exist, very few natural gas fields contain the concentrations necessary to justify a helium separation and recovery operation. The study conducted in the last century revealed the potential for helium exploration and production companies to continue attention to the potential oil resource. With several high concentration helium plays and natural gas wells associated with helium accumulations of or above the 0.3%-economic threshold, Utah deserves the consideration of those interested in exploration for and producing helium.

Helium Extraction and Production

Although extracting helium from the atmosphere is technologically possible, the current method to do so is financially unfeasible. Natural helium is produced as a byproduct of petroleum exploration and production. Non-hydrocarbon gases found in the gas stream are either released or left in the ground. Petroleum exploration and production activities are the primary source of natural gas rich in nitrogen with associated high concentrations of helium can improve the economics of the gas stream and may justify adding a helium recovery unit to gas processing. High purity and transportation costs of refined helium are the primary reasons why the production of helium has historically been driven by the demand for petroleum.

Flow of helium in the commercial supply chain illustrating important stages from initial crude source rock in essential escape beyond Earth’s atmosphere. Modified from Gnyra and Grilli (2016). Although concentrations vary greatly, both Helius’ flow the same general cycle after initial liberation. Dashed lines indicate helium flow processes that are either absent (e.g. secondary migration to atmosphere) or uncommon in the United States (e.g. helium extraction from LNG and helium storage as helium carrier gas). Gas streams entering storage as helium carrier gas can be used to improve helium in large storage tanks or for other applications such as storage or helium exploration and production activities. Transient facilities transfer bulk gaseous and liquid helium into smaller compressed cylinders to be more widely distributed.

Executive Summary

Helium is a rare and valuable resource found in recognizable quantities during natural gas production in very few locations globally, many of which are being actively depleted. The peculiar properties of helium (e.g. inert, non-toxic, lighter-than-air, very cold temperature and small molecular mass) make it an element that can be used in a variety of commercial, industrial, military and research applications as both a liquid and a gas. Continued demand for helium will depend on a range of factors, but for many cutting-edge scientific and medical diagnostic applications helium is unique and has no known replacement.

In the United States, vast amounts of helium associated with non-hydrocarbon gases occur frequently as a byproduct during natural gas production and associated hydrocarbon exploration throughout Arizona, Colorado, New Mexico, Oklahoma, Texas, Utah and Wyoming. Currently, these mid-continent, Cordova region and Colorado Plateau region that are located in eastern Colorado, western, and the Woodside Dome (WS) field on the eastern flank of the north plunging San Rafael Swell and continues through the northern trending Carbon Dioxide Play in the Devolino (CO) and Be 0-86 gas field in eastern San Juan County, Utah. In this region, multiple petroleum reservoirs exist as possible migration pathways for helium and associated non-hydrocarbon gases. Along with mantle degassing processes that may exist in the area and the potential for helium leachate to be retained in the pore space by adsorption into helium rich minerals and transported via intergranular gas migration.

Significant economic helium potential may exist within the extensive, yet relatively unexplored Devonian-Mississippian reservoirs of the Elk Basin Formation, Uinta Limestone and Lower Lime Lime in Utah due to their close proximity to known helium-bearing basement rocks. This helium play comprises nearly 45% of the wells with economic concentrations of helium (0.3%-3%). In the gas stream found in Utah, with the majority sourced from the Mississippi-Mississippi Lime formation. Topped under multiple layers of Pennsylvania salt and ethylene, the Devonian-Mississippian helium play essentially encompasses much of southeastern Utah and the western edge of San Juan County and the Lisbon salt gas field area in San Juan County. On the Navajo Nation farther south, the Boundary Butte field in San Juan County has significant helium shown from analysis taken within the site reservoirs trapped between salt layers of the Paradox Formation.